TOPIC 04 – BONDING
4.5 – PHYSICAL PROPERTIES OF BONDING

IB Chemistry

T04D06

Physical Properties

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4.5.1 Compare and explain the properties of substances resulting from different types of bonding. (3)

- In order to compare the properties of each type of bonding, we will first look at each type of bonding individually

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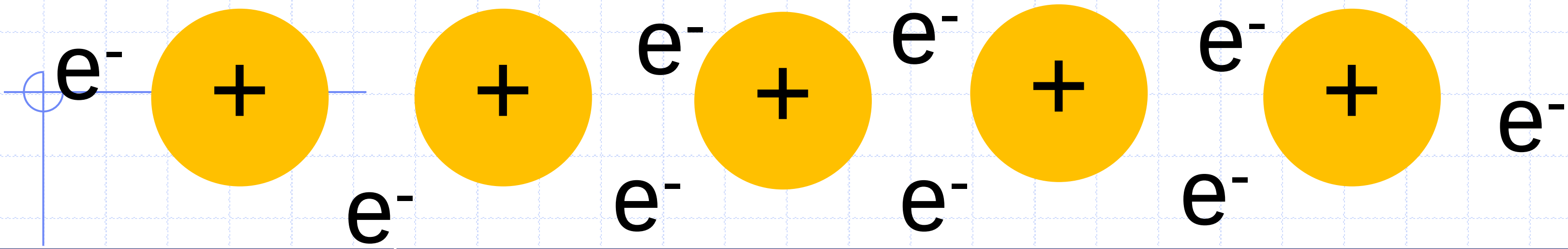
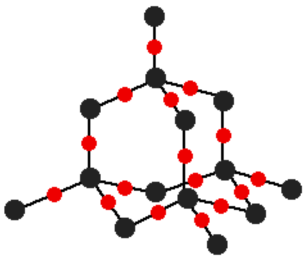
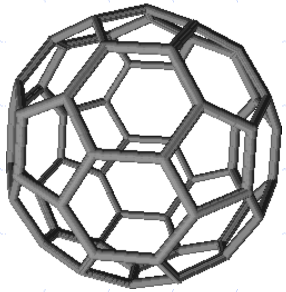
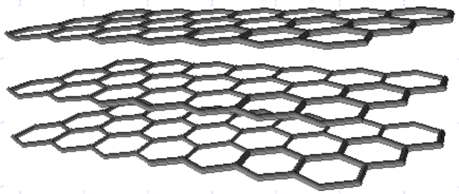
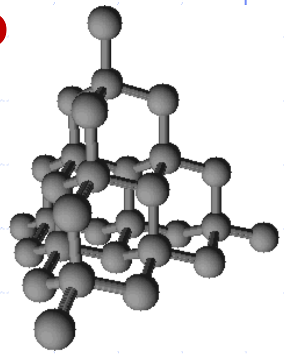
Metallic Structures



Type of Bonding	Metallic
Examples	Na, Al, Fe, Hg, Brass (Cu + Zn)
Composition	Metal atoms
Nature of Bonding	Cations attracted to delocalized valence electrons
Physical State (STP)	Solids (except Hg)
Hardness	Usually hard (group 1 are soft)
Melting Point	Usually high (group 1 and Hg = low)
Electrical Conductivity (Molten)	Conductor
Solubility	Insoluble – but will dissolve in each other to form alloys when molten

Giant Covalent Structures

Type of Bonding	Giant Covalent
Examples	Diamond, polyethene, nylon, SiO_2, graphite
Composition	Non-metallic atoms
Nature of Bonding	Atoms bonded by strong covalent bonds
Physical State (STP)	Solids
Hardness	Extremely hard
Melting Point	Very high
Electrical Conductivity (Molten)	Non-conductors (except graphite)
Solubility	Totally insoluble in all solvents

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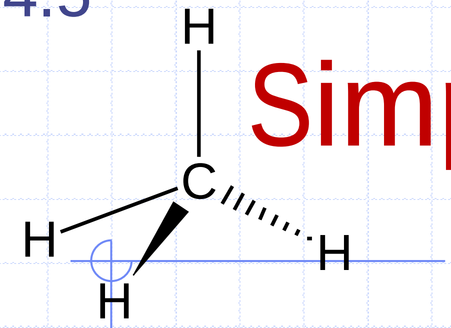
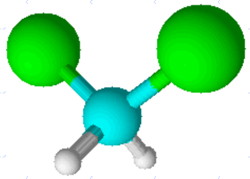
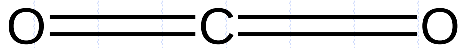
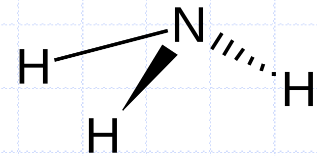
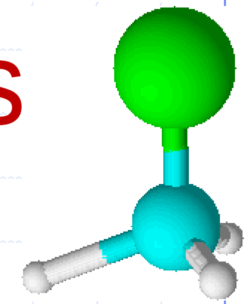
Simple Covalent Structures











Type of Bonding	Simple Molecular (Covalent)
Examples	I_2, CH_4, HCL, H_2O, benzene, carboxylic acids, C_2H_5OH, NH_3, etc
Composition	Molecules
Nature of Bonding	Covalently bonded molecules held together by weak intermolecular forces
Physical State (STP)	Gases, liquids, and solids
Hardness	Soft (if solids)
Melting Point	Very low or low
Electrical Conductivity (Molten)	Usually non-conductors
Solubility	Usually soluble in non-polar solvents; usually less soluble in polar solvents

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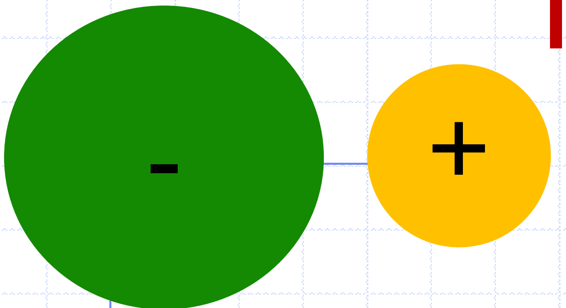
Ionic Structures



Type of Bonding	Ionic
Examples	NaCl, MgO, CaF_2, Na_2CO_3, etc
Composition	Ions
Nature of Bonding	Strong electrostatic attraction between oppositely charged ions
Physical State (STP)	Solids
Hardness	Hard and brittle; undergo cleavage
Melting Point	High
Electrical Conductivity (Molten)	Conductor
Solubility	Usually soluble in polar solvents; insoluble in non-polar solvents

Solubility

- For a material to be considered soluble, it must go through dissolution (dissolving) in three stages
  1. The solids lattice must be broken (**endothermic**)
  2. The intermolecular forces in the liquid (VDW, D-D, HB) must be disrupted to some degree (**endothermic**)
  3. New bonds must be formed between the molecules in the solid and the liquid (**exothermic**)
- Solubility is more likely if the overall enthalpy change is exothermic

Strength of attraction between the molecular solid and liquid molecules in solution

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Combined strengths of attractions between molecules in the pure solid and between molecules in the pure liquid

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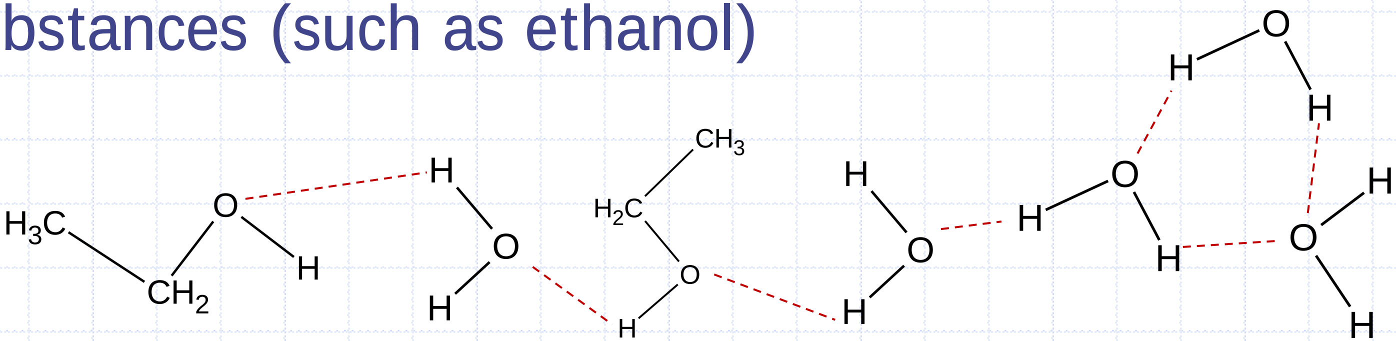
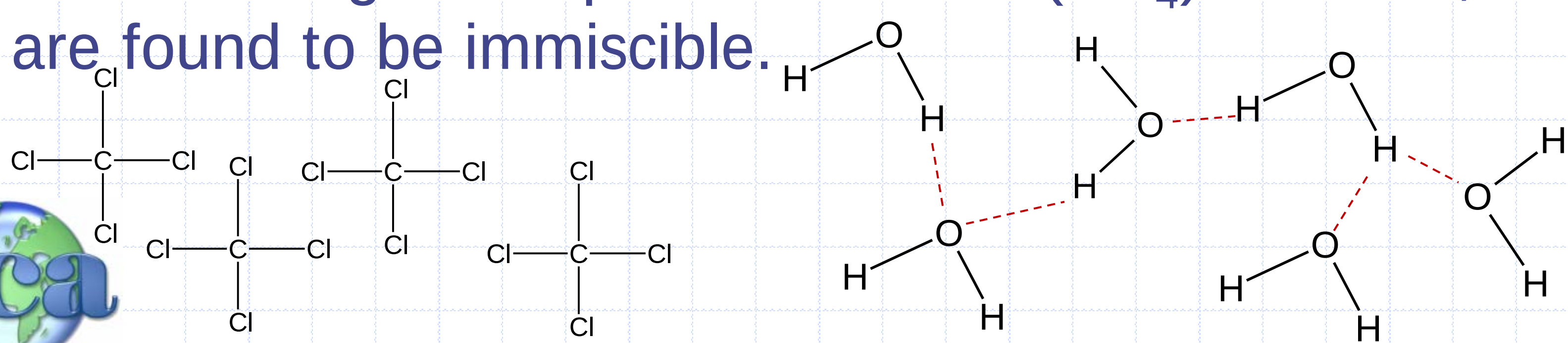
Solubility of Covalent Liquids

- You may follow the general rule of like-dissolves-like
  - A polar solvent (such as water) will dissolve polar substances (such as ethanol)

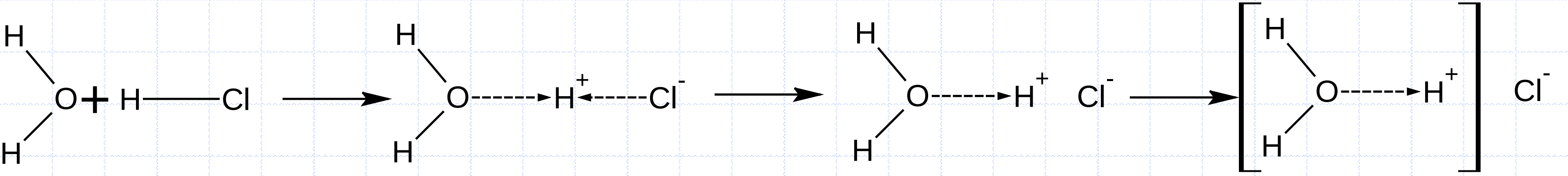


  - A non-polar solvent (such as soap) will dissolve non polar substances (such as oil)
- When adding a non-polar substance (CCl_4) to water, they are found to be immiscible.



Solubility of Covalent Gases

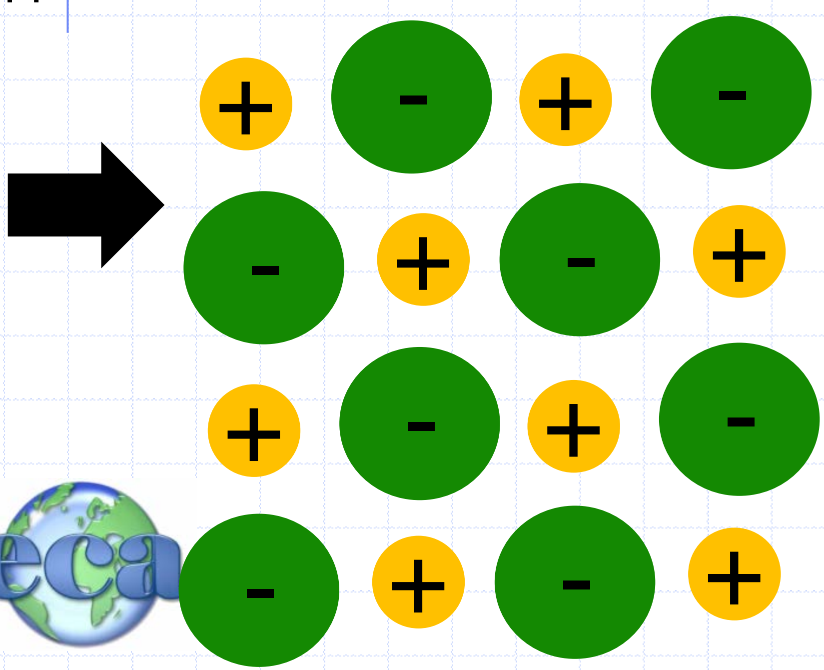
- Gases are only slightly soluble in water (H_2, N_2, etc)
- Only a few gases are highly soluble in water, but this results from the reaction they in water releasing ions allowing them to be soluble.
- Hydrogen Chloride Gas (HCl) is very soluble in water as it reacts to produce H_3O^+ and Cl^- ions
  - $H_2O(l) + HCl(g) \rightarrow H_3O^+(aq) + Cl^-(aq)$



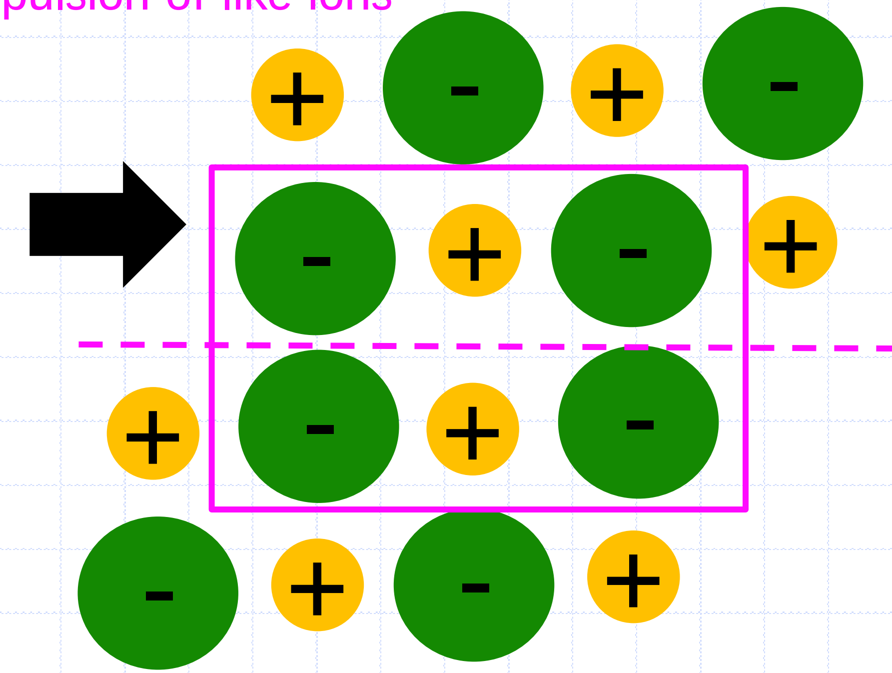
Physical Properties of Ionic Compounds

- The brittle nature of ionic compounds, and the ability to cleave along planes (think grinding salt) results from the **mutual repulsion** present when ions are displaced by an applied force

Applied Force



Repulsion of like ions



Ionic Lattice and Conductivity

- The attractive forces of opposite ions are much stronger than the repulsions of like ions, therefore the an ionic lattice requires large amounts of energy to break up.
  - Results in very high melting and boiling points
- **Conductivity** of Ionic Compounds:
  - When in a **solid lattice**, the electrostatic forces do not allow for the conduction of electricity
  - When **molten** (liquid) or dissolved in **aqueous** solution, the lattice is broken up and ions are free to move and transmit charge